THE VARIATION AND CORRELATIONS OF CERTAIN TAXONOMIC CHARACTERS OF GRYLLUS

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INTRODUCTION.

As a result of the formulation of the doctrine of evolution, the last half-century has been characterized by a zealous study of organic variation from a number of viewpoints. A recent phase of this work, and the natural outcome of the desire to gain exact information upon disputed or doubtful points is the statistical science known as biometry. The following paper is an attempt to apply biometrical methods to the study of the variation and correlations of certain of the taxonomically important characters of a number of closely related species.

Much, of course, depends upon the choice of the material to be used in such a study. In the first place, it ought to be something which is abundant and easily obtained. A satisfactory study of variation can not be made from a few specimens; and when the whole field lies before one it would be foolish to choose a form which would be difficult to procure. It is also desirable that the group selected should be wide-ranging, both geographically and physiographically. Otherwise it can throw but little light upon geographic variation and the influence of the environment. Furthermore, for a study of variation we should select something which is variable. The characters must be measurable and should be things which are not affected by growth or from which the growth factor is easily eliminated.

This latter consideration points to the Arthropods as a valuable source of biometric material. Insects, at least, do not grow after they have reached the easily recognizable adult state. They are, moreover, very abundant and easily collected, and the dimensions of the taxonomic characters of most of them do not change in preservation. Now, of insects there are few more abundant, of a wider distribution, more variable, or possessing characters more easily measured than the common crickets (Gryllinæ). Having this in mind, the following work was carried out upon the typical genus, *Gryllus.*

The work was started under the direction of Dr. C. B. Davenport, who has also kindly read the manuscript. To him, both as teacher at the University of Chicago, where most of the calculations were made, and as Director of the Station for Experimental Evolution of the Carnegie Institution of Washington, where they were completed, I am

under great obligations. I wish also to thank, at this time, those who have helped me to secure data. That part of these data which is used in the present discussion, together with the constants calculated from them, are given in the Appendix. Unless otherwise stated all the measurements are from mature females.

1. THE TAXONOMY OF GRYLLUS NATIVE TO EASTERN UNITED STATES.

De Vries (1904) considers that specific characters are usually sharply defined against one another. They are, according to him, separate qualities more often than different degrees of the same quality. This is not true of the crickets, as they are now named. One species does not possess "units" which the others of the same genus lack, but one species differs from the others merely in the "degree" of common characters. Presence or absence of characters (*e. g.*, mobility of tibial spines, teeth between these spines, etc.) are considered of generic or higher value.

Davenport & Blankinship (1898) have expressed the expectation that biometry would furnish us with a "precise criterion of species" and would, in part at least, clear away the haziness which exists in the taxonomy of most orders of both plants and animals. This haziness is most pronounced where species are based, as they are in the Gryllinæ, upon differences in size of characters common to the different species, and not upon de Vriesian "units." When starting this work I hoped that a statistical study of relatively large collections might bring out several sharply defined groups upon which we could logically fix specific names. The extremely frequent appearance of "*Gryllus* sp." in otherwise detailed taxonomic lists emphasizes the need.

De Saussure, one of the foremost taxonomists of the genus, gave up sharply defining the limits of his own species.

Beutenmüller (1894), considering the crickets of New York and vicinity, groups *luctuosus*, *nigra*, and *neglectus* with *pennsylvanicus;* and *angustus* with *abbreviatus*. As I understand it, he is still of the opinion that we have in northeastern United States only these two species, and that their distinguishing mark is the long ovipositor (18 to 21 mm.) of *abbreviatus* as compared with the short one (12 to 15 mm.) of *pennsylvanicus*. The former is more apt to occur in sandy places and to mature in the spring.

Lochhead (1897) was unable to see any difference between *abbreviatus* and *pennsylvanicus*, although he worked over a large variety of characters, including wing venation. However, fixing upon the fact that "one form, *luctuosus*, has hind wings which project like tails behind the wing-covers," and that this character occurs in both sexes, he was inclined to call this form a distinct species and to refer everything else of this region to *abbreviatus*. This idea is founded upon a mistake, for

the two forms are simple dimorphs. I have bred both long-winged and short-winged individuals from the same female.

Blatchley (1903) says:

> The synonymy of the American species of this genus has become greatly confused, due largely to the fact that foreign writers have attempted to monograph the genus with but a limited number of specimens at hand; and again to the fact that the species, especially the males, are very difficult to separate. Mr. Scudder, in two recent papers,* has in part straightened out this difficulty. However, he, as well as the European writers, has written mainly of specimens collected by others, and has not studied the insects in the field. For this reason Mr. Scudder has stated that but 3 species occur in the northern and central United States east of the Mississippi River. A long series of observations in the field, coupled with a careful examination of a large number of individuals, have convinced me that at least 6 species occur in Indiana. Of these, 2 are believed to be undescribed.

Let us consider the five native species of these six (an introduced species, *domesticus*, was included) in the light of considerable field study and also rather large series. I will take up here only two characters—the ovipositor and the posterior femora. I am certain that the present opinion of the majority of the students of this genus is that the lengths of these and the relation between them are the important taxonomic characters. I have followed out the same line of analysis for the characters considered less important and have reached the same conclusions. Those interested may confirm this for a number of different characters from the data given in the Appendix. The dimensions given by Blatchley as typical of these 5 species are shown in table 1. They are, I think, generally accepted as describing, as far as they go, the species in question.

TABLE 1.—*Typical dimensions of native species.*

Species.	Ovipositor.	Posterior femora.	Ratio of ovipositor to posterior femora.
G. americanus	11.0	11.0	1.0
pennsylvanicus	13.5	12.4	1.1
arenaceus	16.5	11.5	1.4
abbreviatus	18 to 21	13.5	1.4
firmus	23.5	16.75	1.4

Table 2 shows the dimensions of the individuals of the Amherst collection; and, for convenience of reference, the typical dimensions of 4 of the species are indicated. It will be noted that the typical dimensions of *arenaceus* are realized by 2 of the 114 specimens and approached very closely by 15 others. *Americanus, pennsylvanicus,* and *abbreviatus* are just beyond the area of variation. What shall we name the majority of the crickets from Amherst? In the short-winged

*Psyche, IX, 1901, p. 267, *et seq.*; 1902, p. 291, *et seq.*

portion of the June, 1904, collection from Gotha all four of these species are represented, but they are all just on the boundary of the area of variation (table 3). The collection as a whole could scarcely be more exactly intermediate. The dimensions of the very large species *firmus* are not exactly realized in any of my collections, although the large specimen from Cold Spring Harbor (table 53) would probably be so named. Its ovipositor is 2 mm. too large, but the posterior femora are as much too small. In this latter collection *arenaceus* and *abbreviatus* are each represented by a few specimens, but they are at the edge of the range of variation. The Perkins Cove group (table 22) also closely approximates *firmus*. In it *arenaceus* and *abbreviatus* are well in the center of the area of variation.

TABLE 2.—*Amherst, Massachusetts, 1901.*

OVIPOSITOR.

POSTERIOR FEMORA.	10.5	11.5	12.5	13.5	11.5	15.5	16.5	17.5	18.5	19.5	
8.5	1	2									3
9.5		1	6	20	3						30
10.5			3	29	18	6					56
	Am.										
11.5				1	13	8	Ar. 2	1			25
12.5				P.							0
13.5										Ab.	0
	1	3	9	50	34	14	2	1	0	0	114

I might go through any of the correlation tables of the Appendix, or others which I do not publish here, and show the same thing which these tables seem to bring out very clearly, namely, that when we study really representative collections from ever so restricted regions we get perfectly graduated series with respect to a given combination of characters from one named condition to another, or a series which misses, for the most part, all of them. The species have, in truth, been named by Americans as well as Europeans from individuals picked here and there in limited numbers from the range of variation; but, since only the extreme individuals are thought worthy of a name, the vast majority, being mediocre, fit nowhere, unless it be with the mediocre "species" *abbreviatus*, which is usually described as having quite a wide range of variation. Typical specimens of *americanus* and *firmus* are rare for the same reason that very short men and very tall men are rare.

Out of it all there is one thing clear, it seems to me: Either we simply name stages in a great continuous mass of variations and call them

species, or there is but one species of *Gryllus* in eastern United States, and the names we give are not the names of species at all, but simply inaccurate shorthand expressions for recording the approximate size, proportions, and color of the individuals found. In the latter case we need more names. It is scarcely conceivable that the species so named are—all of them, at least—separated by sterility barriers, or that they have any real entity. They are merely *convenience species*.

TABLE 3.—*Gotha, Florida, June, 1904 (short-winged).*

OVIPOSITOR.

POSTERIOR FEMORA.	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	
9.5		1									1
10.5			5	1							6
11.5	Am.	1	9	11	21	2	Ar. 1				45
12.5			1	P. 6	13	27	6				53
13.5						1	6	1	1	Ab.	9
14.5										1	1
		2	15	18	34	30	13	1	1	1	115

Breeding experiments are in progress to obtain more light on this subject. But whether such experiments demonstrate definitely separated groups in our native* crickets or not, we must necessarily keep these specific names or some substitute for them. I have found this same state of affairs in other genera, and I believe it to be very common. It does no good to call them varieties, as that is merely shifting trouble. Besides, if these are varieties, what species are they varieties of? There are about 200 species in the genus and they all appear to be made in much the way that our American species are. The data concerning the relation between the intraspecific and the interspecific constants (see pp. 13–17) certainly do not combat this idea. It would, obviously, be out of the question to go through, not only this whole genus, but the whole organic world, and compute variation curves in order to determine the status of proposed names. If we did we would find more cases of this sort than is generally suspected. And then what could we do? To be specific, what can we do with these data? There can be no precise criterion of species. "Species" is a human concept as much as "genus," and of the same sort. Where there are sharp breaks in the evolution, such as the presence or absence of some character, or even non-intergrading differences of common characters,

*They have not, as yet, although I believe from my experimental work that *G. domesticus* does not interbreed with our native crickets.

there the taxonomist's work is easy. Where there are no sharp breaks, but evolution has proceeded by simply enlarging here and diminishing there, the taxonomist must pick out stages which seem to be important for one reason or another and give them names by which others will recognize what is being talked about. These "species" may not have the distinctness that has been postulated for things of specific rank,* but they are necessary, and they are, as far as we know, the next rank below "genus." We must have shorthand expressions for describing our specimens. I, personally, would prefer a formula such as Teg. 12, P. F. 10, Ovip. 16, but the taxonomic world would probably deny me that privilege; and so, where necessary, the names in common usage must be used and for the sake of convenience we need more of them. However, since I feel that in *Gryllus* these names mean nothing more than rough descriptions of dimensions, and since from the nature of this paper the dimensions are given in detail, I have largely abstained from the use of specific names.

2. COMPARISON OF THE LONG-WINGED AND SHORT-WINGED GROUPS.

In considering the relations between the long-winged and the short-winged groups we should bear clearly in mind the nature of the dimorphism. Brues (1903), writing of insects having vestigial wings, offers the following categories into which he believes it possible to class all such cases:

(1) Wings having essentially a pupal character, *i. e.*, developing as normal wings up to the pupal stage but failing to expand.

(2) Wings essentially normal, except for their smaller size and less complex venation; sometimes even developing a color pattern, or possessing unique and quite distinctive characters.

(3) Wings consisting of little more than a hollow bag and giving no clue from their appearance as to the probable wing-structure of their ancestors. (Comparable in a way to the halteres of the Diptera.)

Class 1 is a very common type among the rather near relatives of *Gryllus.* Whole genera of the Locustidæ, *e. g.*, *Ceuthophilus,* never develop wings beyond the pupal state. *Myrmecophila*, of the Gryllidæ, also comes in this category. But all the species of *Gryllus*, as far as I know them, pass beyond this stage and develop imaginal wings of some sort. The short wings of *Gryllus* fit most nearly Brues's class 2. The short wings are essentially normal in all respects, except for their

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*Sharp (1882) puts this postulate very concisely. He says:

"I believe, if we limit our view to the creatures coexisting at the present moment, no naturalist could be found who would venture to deny the existence of species as real and objective. It is, in fact, perfectly clear that the hosts of individuals living around us are arranged in clusters or groups, *isolated* from other clusters or groups; . . . . no practical naturalist will be found who will deny the reality of the existence and isolation of such clusters, and it is these we call species."

smaller size. The normality extends even to the venation, as can be seen by reference to fig. 1. The slightly different shape merely means that the length is reduced more rapidly than the breadth. I am not certain that objection could not very properly be made to an attempt to class them in the category of "vestigial" wings. They might more properly be called "reduced." We would then have three classes of wings among adult insects—vestigial,* reduced, and normal. Possibly a fourth class, "hypertrophied," may exist, but I can recall no example of it. I would define that wing as "normal" which is just sufficient for the function of flight. A "reduced" wing is one which is normal in all respects except size, but which is too small for flying purposes. "Vestigial" wings are not only small, but present abnormalities of structure.

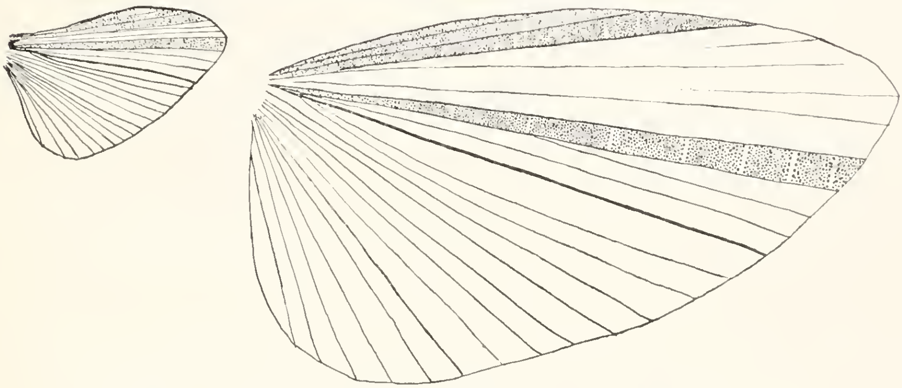

FIG. 1.—Long and short wings of *Gryllus*. Drawn to the same scale.

I think Burr's (1899) paper is an instance of the confusion which results from a failure to keep these distinctions clearly in mind. He states that in Orthoptera "as the female is larger and heavier than the male, it is in the female that the abbreviation occurs more frequently." The data given in table 11 do not support this idea, when applied to reduced wings of *Gryllus*. However, not only among Orthoptera, but among insects in general, the female is more apt to have vestigial wings of Brues's type 1 than the male. Another statement in the same paper by Burr does not hold when applied to the wings of *Gryllus*. He says: "As the female increases in size, so the elytra and wings diminish, varying in inverse ratio with the magnitude of the creature." This would amount to a negative coefficient of correlation, and I have found none such, either when studying local collections or when con-

*Brues seems justified in dropping the term "rudimentary" in this connection. Unless it can be proven that we have adult insects with poorly developed wings whose ancestors never had any better, we can not speak of the poorly developed wings of these adult insects as being "rudimentary." They are either "vestigial" or merely "reduced."

sidering the genus as a whole. Furthermore, the mean lengths of all the organs are smaller in the group having reduced wings than in the long-winged group.

The Gotha, Florida, collection presents an opportunity to study the biometric relations between long-winged and short-winged groups, all the individuals of which had lived in the same environment. Differences between an all-long-winged collection, such as the Cuernavaca one (see p. 55), and an all-short-winged one may be correlated with the wing-differences; but, on the other hand, they may be due to differences in the environment during the growth of the individuals contained in the two collections. However, any significant differences between the two groups of the Gotha collection (see p. 46) must certainly be related in some way to the distinguishing character—the wing dimorphism—for all the individuals of both groups came from the same field and were collected at the same time.

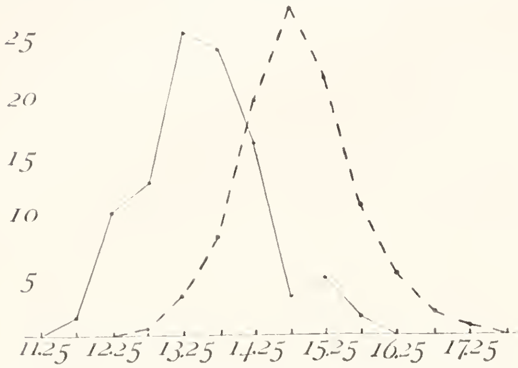

Fig. 2.—Polygons of frequency for the tegmina at Gotha, Florida. ————, short-winged group; — — — —, long-winged group.

Table 4.—*Difference between the constants of the short-winged and long-winged groups from Gotha, Florida.*

	Mean.	Standard deviation.	Coefficient of variation.
Body	— 0.490±0.15	+0.019±0.10	+0.27±0.53
Tegmina	— 1.344±0.08	+0.047±0.06	+0.86±0.41
Wings	12.076+0.11	—0.201±0.08	+3.72±0.57
Posterior femora	0.251±0.09	+0.101±0.06	+0.91+0.48
Ovipositor	0.762±0.11	+0.118±0.08	+1.03±0.48

In table 4 are given the differences between the respective constants of the two groups as shown in table 56. When the constant for the short-winged group is larger than that for the long-winged one, the difference is given as positive; negative in the opposite case. It is apparent that, with respect to the means of all the organs studied, the long-winged group is significantly the larger. This is a conclusion which could not have been reached *a priori* or from the positive correlation noted between the wings and the other organs, as the two groups are not the upper and lower extremes of a continuous range of fluctuation of wing-length. The wing-length seriations, as shown in

table 55, form two distinct curves, each fluctuating according to the law of error about its own mean. It is not surprising to find that the greatest difference is in the length of the tegmina. It is 16 times the difference which might have been expected in random samples. It is least in the case of the body and the posterior femora, being in them barely significant. The tegminal polygons are shown in fig. 2. Both series are plotted on a per centum basis.

In comparing the variability of corresponding organs in the two groups of this dimorphic population our conclusions will differ according to our views concerning the relative value of the "standard deviation" and the "coefficient of variation." The coefficient of variation is that per centum which the standard deviation is of the mean. Being abstract numbers, all such coefficients are immediately comparable. It seems to me more reasonable to use the coefficient of variation than the standard deviation when the series compared have different means, even if the variates are measured in the same units. The standard deviation is usually, although not necessarily, larger for series having large means than for those having small means. For example, the standard deviation of the weight of men is about 16.5 pounds. The average weight of new-born boys is 7.3 pounds. It would be absurd to think of a standard deviation of 16.5 in the latter case. As a matter of fact, it is about 1.1 pounds. However, considering the coefficient of variation, we reach comparable results and find that infant weights are nearly half again as variable as adult weights instead of being much less. Turning to table 4, we see that the coefficients of variation of the long-winged group are less throughout than those of the short-winged one. The difference is greatest in the case of the wings.

TABLE 5.—*Differences in correlation between short-winged and long-winged groups from Gotha, Florida.*

	Tegmina.	Wings.	Posterior femora.	Ovipositor.
Body	$+0.027 \pm 0.07$	$+0.060 \pm 0.08$	-0.031 ± 0.08	$+0.113 \pm 0.06$
Tegmina		-0.070 ± 0.02	$+0.088 \pm 0.03$	-0.009 ± 0.04
Wings	-0.070 ± 0.02		-0.054 ± 0.06	-0.033 ± 0.05
Posterior femora	$+0.088 \pm 0.03$	-0.054 ± 0.06		$+0.066 \pm 0.04$
Ovipositor	-0.009 ± 0.04	-0.033 ± 0.05	$+0.066 \pm 0.04$	

Table 5 gives the differences between the respective coefficients of correlation in the two groups, the signs having the same significance as in table 4. In only one case—the tegminal-wing correlation—is the difference equal to three times the difference which might have been expected from random samples, and hence it alone can be considered as having any significance. Even it is not very great. The table as a whole shows the correlations in the two groups to be practically equal.

The regression lines are interesting, since they give us the plan, so to speak, upon which the crickets are made. The equations for determining the probable length of the several organs for a given wing-length, together with the probable error of the coefficient of regression, are given in table 6. It is to be noted that in no case is there a marked difference between the two groups in the regression coefficients (the multiplying constants in the equations). However, the slight difference is, in each case, in the same direction, *i. e.*, larger in the short-winged group. What this means is best explained by reference to fig. 3, which shows the position of a pair of the regression lines and also

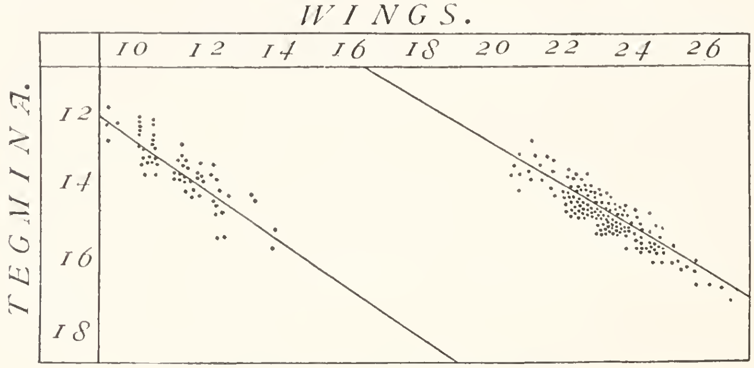

FIG. 3.—Regression lines of tegmina on wings.

the distribution of the individual crickets studied, each cricket being represented by a dot. The lines, instead of being parallel, as they would be were the regression coefficients equal, approach each other toward the smaller dimensions. In other words, in each group *pari passu* the decrease in wing-length the other organs decrease, but they decrease rather more rapidly in the long-winged group than in the short-winged one. As stated above, the difference is very slight, and we may say that, in a general way, the influences which brought about this marked dimorphism of wing-length have not greatly affected the structural relations between the wings and the other organs studied.

TABLE 6.—*Certain regression lines of the Gotha collection.*

Short-winged.		Long-winged.	
Regression lines.	P. E. ρ.	Regression lines.	P. E. ρ.
Body 0.376 wing+11.097	0.053	Body 0.270 wing+12.936	0.028
Tegmina 0.698 wing+ 5.642	0.035	Tegmina 0.599 wing+ 0.856	0.013
Post. Fem. 0.504 wing+ 6.914	0.052	Post. Fem. 0.410 wing+ 3.263	0.023
Ovipositor 0.799 wing+ 6.984	0.066	Ovipositor 0.613 wing+ 2.163	0.031

Skewness, in a biometric sense, is that condition of the distribution of frequencies in which the average dimension differs significantly from

the most common one. In other words, the variation curve, instead of being symmetrical is one-sided. The tendency of biologic frequencies seems to be to group themselves symmetrically about the most common condition. Whenever there is a deviation from this "normal" distribution it is worthy of note. In the only two cases of dimorphism, similar to the present one, which have been studied (Davenport, 1901) a marked skewness has been found and the two curves were skew toward each other. The value of the third moment (μ_3) of the curve about its mean forms a test of symmetry. In symmetrical curves it is zero within its probable error of $0.6745\sigma^3\sqrt{\frac{6}{N}}$, where $\sigma =$ the standard deviation and $N =$ the number of individuals. The sign of μ_3 indicates the direction of the skewness. Table 7 gives these values for this material and shows a condition which is rather surprising. None of the curves show a marked asymmetry, all the third moments being less than three times their probable errors.

TABLE 7.—*Third moments of the Gotha, Florida, collection.*

	Short-winged.	Long-winged.
Body	$+0.265\pm0.602$	$+0.706\pm0.378$
Tegmina	$+1.476\pm0.910$	$+0.794\pm0.485$
Wings	$+2.692\pm1.648$	$+2.387\pm1.836$
Posterior femora	$+1.909\pm0.898$	$+0.446\pm0.373$
Ovipositor	$+1.495\pm2.124$	$+0.048\pm0.978$

To sum up this section, the Gotha collection is strikingly dimorphic with respect to wing-length. Dimorphism is noticed, to a lesser degree, in the other organs. The short-winged group is slightly more variable than the long-winged one. The correlations and regressions are practically the same in both cases. The variation curves are symmetrical.

3. COMPARISON OF INTRASPECIFIC AND INTERSPECIFIC CONSTANTS.

The opportunity here presented to study the relation between intraspecific and interspecific constants for a number of organs of a lower animal is, I believe, novel. The data are given in the Appendix. The viewpoint in this section is that the genus *Gryllus* is a unit. In obtaining the material for the preceding sections individuals selected at random from one locality at one time were used. I wish now to consider the species in the light of an individual, and to study specimens collected from here and there, all over the world, having only this in common, that they are all of one sex (female) and that they all belong to the genus *Gryllus*. To do this I went to the British Museum and by the courtesy of the authorities measured their entire collection of *Gryllus* females. There were about 175 of these and only occasionally was

more than one from the same locality. Furthermore, no one species was represented by an extra large number of specimens. I have also embodied in my data the measurements given by de Saussure (1876–77) as typical of various species. There are about 30 of these. In this way data of the genus as a whole have been procured as nearly representative as possible.

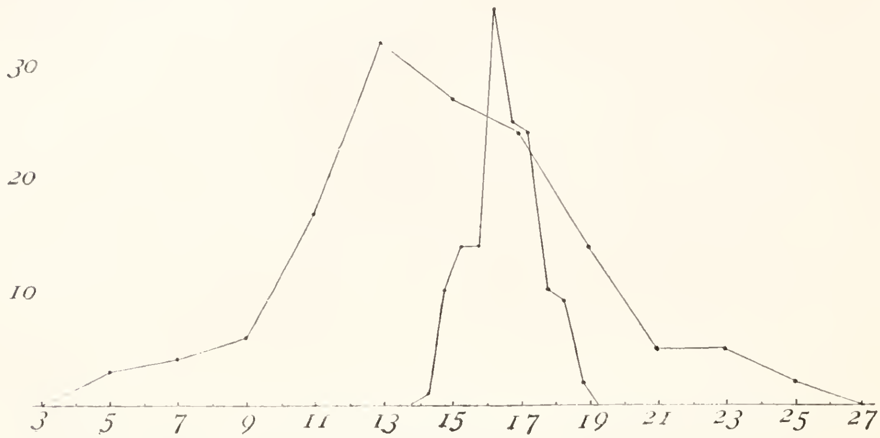

FIG. 4.—Polygons of frequency for interspecific and intraspecific (Gotha, Florida) ovipositor lengths.

By "intraspecific" here, the population of a single restricted area is meant. Since "species" is, in this material, such an indefinite term, "intraspecific" is not very fitting, but with the discussion of section 1 in mind its special meaning in this case will be readily understood.

TABLE 8.—*Comparison of intraspecific and interspecific variability.*

	Average intraspecific coefficient of variability.		Interspecific coefficient of variability.	
	Short-winged.	Long-winged.	Short-winged.	Long-winged.
Body	7.57	6.88	20.39	17.82
Tegmina	9.81	5.19	31.57	18.53
Posterior femora	6.52	5.31	20.36	19.06
Ovipositor	7.97	5.82	29.64	26.60

It is to be noted, in the first place, that the interspecific variation curves (table 79) are of the familiar error type. The mediocre species, like the mediocre individuals of a local collection, are the most common. The extremes are rare. Fig. 4 shows the polygon of ovipositor lengths for the long-winged group of the genus as a whole and also the one for that long-winged portion of the genus which was found at Gotha, Florida, September, 1903. It gives a graphic idea of the relation between the range of variation of a moderately variable local collection and of

the entire generic range. Fig. 5 presents the same idea in another form. In it are given the regression lines of the posterior femora on the ovipositor for the genus as a whole and also for three local collections of *Gryllus* from widely separated areas. The lengths and positions of these lines show the range of variation in the different collections and also the relative proportions of the ovipositor and the posterior femora in each. As previously stated, this relation is important from a taxonomic standpoint. It is apparent that while there are differences between the various regression lines, the general trend of regression is the same, not only in local samples of the genus, but in the genus as a whole.

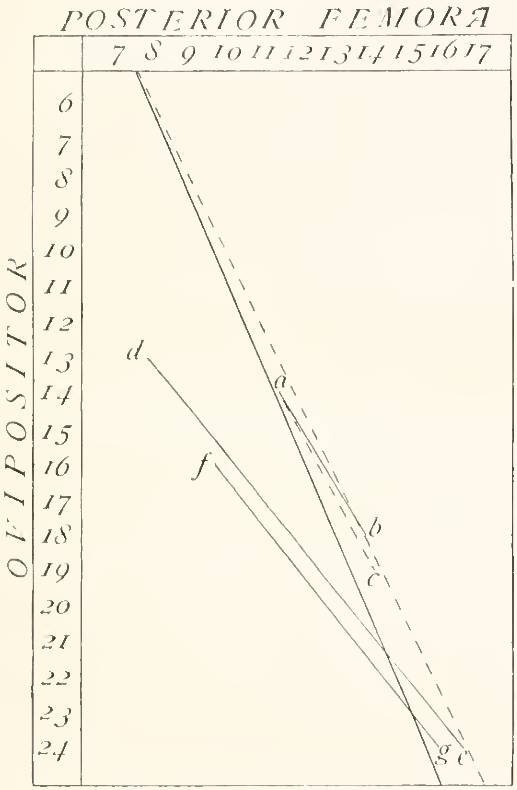

FIG. 5.—Intraspecific and interspecific regression lines of posterior femora on ovipositor. Solid lines, short-winged groups; broken, long-winged. *a b* and *a c*, Gotha, Florida.; *d e*, Perkins Cove, Maine.; *fg*, base of spit, Cold Spring Harbor, New York. The other pair are the interspecific regression lines.

As would be expected, no one local collection presents as wide a range of variation as the genus as a whole, but the relative amount of variation seems to me surprisingly large. In table 8 I give the average coefficients of variation as found in the Maine, Massachusetts, New York, and Florida collections, and, for comparison, the interspecific coefficient of variation. The coefficients for the body-length are here included merely for completeness, because taxonomists often make use of this character. I consider the body-length constants of very little importance in a study of variation, as the length of the body is dependent upon factors of no evolutionary interest, such as the size of recent meals or, in the case of the females, the number of unlaid eggs. Considering the other organs, there is a striking parallelism between the intraspecific and the interspecific coefficients of variation with respect to the relative variability of these organs. The data indicate that both in the short-winged portion of the genus as a whole and, on the average, in local collections of short-winged *Gryllus*, the tegmina are

more variable in length than the ovipositor, and the posterior femora are less variable than either; while the order of variability for the long-winged portion of the genus and also for the long-winged portion of the Gotha collection—the only local collection I have which gives such data—is ovipositor, posterior femora, tegmina.

TABLE 9.—*Comparison of intraspecific and interspecific correlations.*

[*a*, short-winged; *b*, long-winged.]

		Tegmina.		Posterior femora.		Ovipositor.	
		Intra-specific.	Inter-specific.	Intra-specific.	Inter-specific.	Intra-specific.	Inter-specific.
Body	*a*	0.616	0.719	0.538	0.862	0.700	0.720
	b	.575	.864	.569	.854	.557	.699
Tegmina	*a*			*.803*	.701	*.736*	.541
	b			.773	.839	*.776*	.709
Posterior femora	*a*	*.803*	.701			*.779*	.739
	b	.773	.839			.770	.816
Ovipositor	*a*	*.736*	.541	*.779*	.739		
	b	*.776*	.709	.770	.816		

Table 9 offers a comparison of the intraspecific and the interspecific correlations. The intraspecific coefficients of correlation are averages obtained from the same collections as were the average coefficients of variation given in table 8. Those intraspecific coefficients which are larger than the corresponding interspecific ones are italicized. Here, again, not much stress can be laid upon the constants involving body-length. The table seems to indicate that, on the whole, the intraspecific correlations between these various organs are approximately equal to the interspecific. There is, at any rate, no constant difference, and such differences as there are are not great, considering the probable errors.

TABLE 10.—*Interspecific third moments.*

	Short-winged.	Long-winged.
Body	$+1.138 \pm 1.324$	-1.360 ± 0.659
Tegmina	$+0.362 \pm 0.790$	-1.481 ± 0.248
Posterior femora	-0.078 ± 0.345	$+0.045 \pm 0.227$
Ovipositor	-0.917 ± 1.680	$+0.664 \pm 1.055$

This similarity of conditions in the genus as a whole and in separate portions of it is further illustrated by the relation between the long-winged and the short-winged dimorphs. Table 80 shows that the means of all the organs studied of the short-winged group of the genus are

smaller than the means of these same organs of the long-winged group. Also, the long-winged group is less variable than the short-winged one. These are exactly the relations holding in the Gotha collection. Table 81 shows that there is a slight difference in the correlations in the two groups of the genus as a whole. The long-winged group has its organs more closely correlated than the short-winged one. The single exception—that between the body and ovipositor—is not significant when we consider the probable errors and also the fact that the body-length is an untrustworthy character. This stronger correlation in the long-winged group is somewhat apparent also in the Gotha collection, but is not very marked.

Table 10 gives the third moments for the genus as a whole. The polygon of frequencies for the long-winged tegmina is significantly skew toward the short-winged condition. The other polygons are approximately symmetrical, as was the case with the Gotha collection. I regret that it was impossible to get data as to the interspecific wing-length constants. They would probably show significant skewness.

The conclusion to be drawn from this section is, it seems to me, that the local populations of *Gryllus* are merely *samples* of the genus as a whole; and, although presenting sufficiently diverse values to entitle them, or at least portions of them, to specific distinction, they are not, as far as these taxonomically important organs indicate, organically different either from each other or from the genus as a whole. The only sharply defined groups in the genus appear to be those based upon the dimorphism of the wing-length, and even these two groups may be derived from a single female, and they freely interbreed in nature.

4. THE EFFECT OF LOCAL DIFFERENCES IN THE ENVIRONMENT.

The distribution of *Gryllus* within an area seems to be determined chiefly by food-supply and shelter. It is not a grass-lover like the closely related *Nemobius*. Its food is dried organic material, such as rags, dead grass, rotten wood, partly dried cow-dung, and on beaches, seaweed, shellfish, etc. All of these things also afford shelter.

Uhler (1889) noted that *G. pennsylvanicus* (short ovipositor) is found on loamy soils, while on the sandy beaches in the same general locality the crickets have longer ovipositors. The relation between the character of the soil and the ovipositor—hence, also, species—is well brought out by my three collections from Cold Spring Harbor. These collections were all made at the same time and from localities within several hundred meters of each other.

There projects from the west side of Cold Spring Harbor a sand-spit 660 meters long and having an average width of about 50 meters. The chief vegetation on the spit is *Ammophila arenaria*. Along its edges

there is always a mass of flotsam and jetsam, and under these *Gryllus* is very abundant. *Nemobius* does not occur, except near the base of the spit where the sand-grass is fairly thick. The majority of the specimens in the "apex of spit" collection came from the very tip of this spit. The majority of those in the "base of spit" collection were caught within 50 meters of the actual base. Very few in either collection came from near the boundary between the two areas, which, for convenience, I put at a county-line landmark near the middle of the spit. The "mainland" collection is from an area of about 5 ares at the head of the harbor, just above the storm high-water mark, along the edge of the salt-marsh. The soil of the latter locality contains considerable humus, supporting a fair growth of *Poa*. The soil at the apex of the spit is practically clear sand. That of the base is sand, with a small amount of humus.

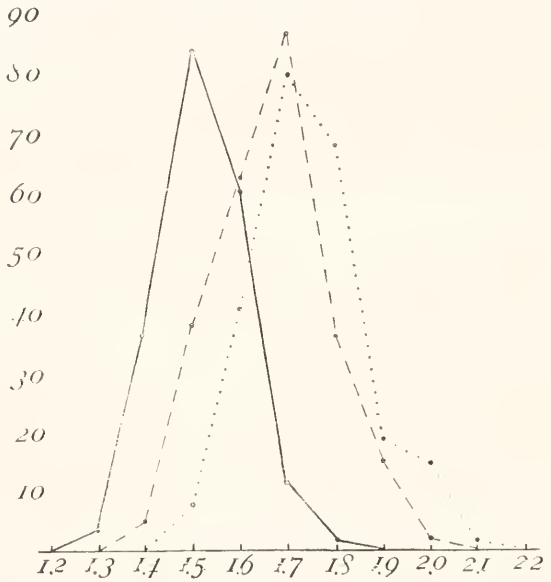

FIG. 6.—Polygons of frequency for ratio of ovipositor to tegmina for mainland (————), base of spit (— — — —), and apex of spit (. . . .) at Cold Spring Harbor, New York.

Over 200 females from each of these three places were measured. Referring to the results (table 34), we see that the average lengths of the ovipositor differ to a great extent and that the differences are progressive, *i. e*,. the length of the ovipositor increases as we pass from the mainland to the tip of the spit, being on the average about 18 mm. on the mainland, 19 at the base of the spit, and 20 at the apex. The tegminal and wing differences, while not so large, are also progressive, and, considering the probable errors, are doubtless significant. It is interesting that these organs both grow shorter instead of longer as we pass from the mainland to the apex of the spit. The lengths of the posterior femora are the same in each of the collections. In other words, there is not only a progressive change in size, most marked in the case of the ovipositor, but a striking change in proportions. In fig. 6 I have plotted the polygons of frequency for the ratio of ovipositor to tegmina in order to show this graphically.

The differences in variability (see table 34) are not so striking. In general, the coefficients of variation are greatest in the collection from

the base of the spit (average, 8.48) and least in the one from the apex (average, 7.76). Since the means on the mainland and at the apex of the spit markedly differ, we would expect that the variability of the crickets occupying the middle ground would be greater than that of either of the extremes. This is on the supposition that the crickets at the base of the spit are a mixture of migrants from the two extreme populations and also of the population proper to that area. However, crickets do not move about much, and it may be that the greater variability at the base is connected with the greater variation in the constitution of the soil and other factors of the environment. A third idea is that optimum conditions favor great variability. Judging from the relative abundance of individuals, the most favorable of the three areas for *Gryllus* is the base and the least favorable is the apex of the spit. Lastly, selection may be instrumental in reducing the variation at the latter place. Tower, Crampton, Bumpus, and Weldon have shown that selection acts this way. Doubtless many crickets are killed by other animals, but it is difficult to see how there would be much selection in this killing. However, the winter is passed in the egg state, the eggs being laid singly in the ground. Wherever the soil is loose—as on the sand-spit, especially at the apex—those eggs which are not deeply placed will almost certainly perish. In this way selection acts against the offspring of females having short ovipositors where the soil is loose. It is to be noted that the length of the ovipositor increases as the looseness of the soil increases. A small collection from the middle of the spit had an average ovipositor-length of 19.52 mm. or about midway between the lengths of the ovipositor of the base and of that of the apex populations, while those from the mainland had the shortest ovipositors.

The few *Gryllus* collected in the grass-fields about Perkins Cove, Maine, had an average ovipositor-length of 14 mm., while of the 147 females from the cove collection (see p. 27), which had passed the winter as eggs in the beach-sand, only 2 had so small an ovipositor and the average was nearly 19 mm. Which of these four suggestions, if any, explains the differences of variability at Cold Spring Harbor can, at present, be nothing more than a matter of discussion. It is difficult to obtain conclusive experimental evidence. Pearson (1902) states that selection decreases correlation. In these collections the average coefficient of correlation between the various organs here considered is 0.70 at the apex as compared with 0.74 at the base and 0.73 on the mainland. To take a specific organ, the only one showing progressive differences is the ovipositor. It has an average coefficient of correlation of 0.64 at the apex, 0.67 at the base, and 0.72 on the mainland. This is, furthermore, the organ in which we would expect progressive

differences upon the soil-selection hypothesis, and the differences are in the direction which this idea would require. These things, taken in connection with what follows, make a fairly good case for this contention.

Blatchley's species, *arenaceus*, is characterized by a long ovipositor as compared with the body and tegmina. As its name implies, it is "sand-loving." Blatchley found it in "bare sandy places" in the dune region of Lake Michigan. The poor food-supply in such places would easily account for its small body and tegmina, but why was not the ovipositor reduced also? It seems to me that we have a sufficient answer in the necessity of the creatures' laying their eggs deep in the sand. If the ovipositor were not long, the eggs wintering over nearer the top of the sand would be much exposed to the rigorous climatic conditions of the dune region, even if they were not actually uncovered by the shifting of the sand. It seems to be an adaptive reponse, brought about by selection, to the condition of the soil, just as in the Cold Spring Harbor collections, and, in this case, it gave rise to a "species."

In most localities there is an early-summer-maturing group and a fall-maturing group or brood. These are supposed not to interbreed.* The members of the early-maturing group usually have shorter ovipositors than those of the late-maturing one. The former includes *pennsylvanicus* and *americanus;* while *arenaceus, abbreviatus,* and *firmus* make up the latter group. Compare in this connection the two Orono, Maine, collections: October, 1904, average ovipositor-length, 12.9; June, 1905, 11.1. The average ovipositor-length at Gotha, Florida, September, 1903, was, short-winged 15.7, long-winged 16.5. The June, 1904, brood at the same place gave 14.6 and 16.4, respectively. I think we have here again a simple adjustment of the length of the ovipositor to environmental conditions, the long-ovipositored group having to winter over in the egg state, while the eggs of the short-ovipositored group develop in a few weeks in midsummer.

These three lines of evidence—the Cold Spring Harbor and Perkins Cove collections, the unconscious testimony of a taxonomist, and the relation between the summer-maturing and the fall-maturing groups—seem to indicate that the length of the ovipositor is a function of soil and weather; also that the active factor in the equation is selection. I am attempting to study this point experimentally, but at the best will not be able to report for several years.

Concerning the relations between the other organs and local conditions of the environment, I have at present little definite to offer. The

*I doubt this, as all of the fall-maturing group which I have been rearing in a cool, shady place are still (in October) immature and will not mature before next spring, when they will have a chance to mate with individuals of the summer-maturing group.

amount and quality of the food is probably one of the important factors. At Cold Spring Harbor the posterior femora show no significant differences in the three areas, but the tegmina and wings do, decreasing as the ovipositor increases.

The apex of the sand-spit is connected with the mainland only via the base of the spit; and, as these short-winged crickets neither swim nor fly, the *Gryllus* population of this area must have come from the base of the spit. We must consider that the characteristics of the apex population have been derived from those of the base population either by selection with respect to the size of one or more organs (and the consequent modification of all organs correlated with these), or by non-selective modifying influences, or by a combination of the two. We have some evidence to support the view that the ovipositor has been selected for greater length, thereby decreasing the variability and correlations. If we select from the base population a group having the same mean and variability of the ovipositor as that of the apex population, would we get a group closely resembling the one actually found at the apex? This could be done by means of Pearson's (1902) methods. However, it is not necessary to go into this rather involved bit of mathematics, as inspection will give a very definite answer. There are strong positive coefficients of correlation between the ovipositor and the other organs. Therefore, the group selected from the base population with a view to increasing the length of the ovipositor would have greater mean lengths of tegmina, wings, and posterior femora than the parent population. But just the opposite is true of the natural apex group. The selected group differs more widely from the apex population than the base population taken as a whole. On actual calculation it was found that the case of the tegmina is the worst, the difference of the means being 18 times the probable error of the mean of the apex, so that it seems certain that the differentiation of the organs other than the ovipositor has not been brought about solely, at least, through the differentiation of the ovipositor and the consequent modification of the others due to correlation. What the factors—factors which act strongly enough to more than overcome the positive correlation between the ovipositor and tegmina, for instance—are, I can not say. The points I wish to make now are that there are real differences between the populations in these three closely situated habitats, and that the differences in the ovipositor are probably connected with soil differences.

5. GEOGRAPHIC VARIATIONS.

Environmental influences are usually classed as "edaphic" and "climatic." Edaphic factors are, properly speaking, soil factors, but the term may be used in a more general sense to include all environmental influences which are local in character. We were concerned with these in the preceding section. Climatic factors, except in mountainous regions, differ but slightly in not distantly separated localities. Geographic variation is usually, although not necessarily, a function of these climatic factors, past and present, of the environment.

TABLE 11.—*Average lengths of ovipositor, tegmina, and wings, and the relative abundance of the wing dimorphs at various localities.*

	Short-winged.			Long-winged.			Percentage of long-winged individuals.	
	Ovipositor	Tegmina.	Wings.	Ovipositor	Tegmina.	Wings.	Males.	Females.
Millinocket, Maine.	13.1	9.1	6.75	......	......	......	0	0
Orono, Maine (October)	12.9	8.9	6.4	......	......	......	0	0
Orono, Maine (June)	11.1	9.9	7.9	......	......	......	0	0
Perkins Cove, Maine	18.8	12.5	9.8	19.2	12.4	......	3	11
Essex Junction, Vermont	16.8	11.6	8.8	......	......	......	0	0
New Fane, Vermont	16.7	11.0	8.0	......	......	......	0	0
Amherst, Massachusetts	13.9	7.7	5.5	......	......	......	0	0
Cold Spring Harbor, New York	19.1	11.7	8.3	......	......	......	1	3
Blacksburg, Virginia	12.7	10.1	8.3	11.5	11.5	21.0	0	12
Danbury, North Carolina	13.5	10.8	8.8	14.2	14.2	23.8	15	23
Gotha, Florida	15.7	13.5	11.3	16.5	14.9	23.4	82	71
Cuernavaca, Mexico	......	......	......	16.0	13.4	22.6	100	100

From table 11 it seems that there is no relation between latitude and the length of the ovipositor. We have just seen that there is, apparently, a close relation between the length of the ovipositor and the edaphic environment. We might expect that, given the same sort of soil, the ovipositor would be longer in the north than in the south. Such does not seem to be the case. From observation, the conditions at Perkins Cove, Maine, seem to be similar to those at the base of the spit at Cold Spring Harbor, New York, except for the differences in climate. The length of the ovipositor is also practically the same. Unfortunately, these are the only two localities which I can compare from personal observation. They are both beach populations. If we compare the Amherst, Massachusetts, collection (from "fine soil mixed with clay") with the Gotha, Florida, collection ("stony waste land"), we find that the ovipositor of the northern lot is shorter than that of the southern one, but the difference is only a trifle more than that between the two extreme collections from Cold Spring Harbor, and may be accounted for by soil differences. In other words, it seems that

for the ovipositor edaphic influences are more potent than differences of the environment due to geographic position. This is strikingly brought out when we compare the four Maine collections and also the three from Cold Spring Harbor.

The case of the wing-length is rather different. Table 11 shows the relative abundance of the long-winged and the short-winged dimorphs for a number of localities. Taxonomic literature is united in stating that specimens of long-winged *Gryllus* are rare or lacking in northern North America. They are practically absent from the vicinity of Chicago, judging from extended collecting during three years. The 10 specimens I have from Fort Collins, Colorado, are all short-winged and, as they are a museum lot, long-winged specimens would have been preserved had they been found; 25 of the 68 from Corvallis, Oregon, are long-winged. I am not sure that the latter lot is a fair sample, being a museum collection kindly given me. They, however, show that long-winged individuals are common there.

Considering these data, it seems that the long-winged form is characteristic of warm, moist regions. Taxonomists bore witness to the same thing in the related genus *Gryllotalpa* when they named the short-winged form *borealis*.

There is an interesting paleontological point which bears upon this discussion. A number of crickets have been found in the Green River deposits of Wyoming. They resemble the present-day crickets very much and they are all long-winged. The Green River beds belong to the Eocene epoch—an epoch which evidently had a very mild if not tropical climate. The long-wingedness of the crickets may be connected with this fact.

Considering only the short-winged group, we see in the mean wing-lengths of the five collections from Massachusetts to Florida a gradual increase as we go southward. In the Maine and Vermont collections—excepting Perkins Cove and, possibly, Essex Junction—the wing-lengths, while longer than at Amherst, are shorter than in the other collections from farther south.

Many more collections are needed to establish a general law, but there appears to be a tendency, not only for an increased percentage of macropterous individuals with increased climatic heat (and moisture?), but also for an increase in the size of the wings within the micropterous group. Here again, however, local conditions overrule geographic conditions. Witness the Perkins Cove, Maine, lot with 11 per cent macropterous females and a micropterous group with an average wing-length of 9.8 mm.

The tegminal length is very closely correlated with the wing-length. This is true in both the long-winged and the short-winged groups. It

is also true that in a dimorphic population the long-winged group has a greater mean tegminal length than the short-winged one. A glance at table 11 shows that, while there is a tendency for the tegmina to increase as we go southward, it is not so marked as in the case of the wing-length. Probably geographic influences have little direct effect. The size of the tegmina may be the resultant of local environmental influences upon them and their organic correlation with the wings, which are modified by climatic influences.

It is difficult to take a satisfactory world-wide survey of this subject, because of the lack of data and the practical impossibility of supplying this deficiency. However, the data I have for the genus as a whole do not show any constant relation between geographic distribution and either size or proportions of the organs studied. This fact, taken in connection with the results of the study of the collections from the United States, indicates that the susceptibility of *Gryllus* to local environmental conditions overcomes or masks any tendency to geographic variation which may exist, except as regards wing-length.

6. THE BEARING OF THE DATA UPON THEORIES OF EVOLUTION.

It should be borne in mind, when considering the bearing of the facts here presented upon current theories of evolution, that *Gryllus* is not an exceptional case. As I have mentioned before, specific distinctions in this genus are just as sharp and based upon the same sort of characters as the species in other genera, not only of the Gryllidæ, but of other famlies of the Orthoptera and also of other orders of animals. *Gryllus* and *Nemobius* are very common insects, and the intergrades, so troublesome to taxonomists holding the specific entity idea, are met with rather frequently. But the intergrades are just as certainly present in other genera; only, since so many specimens of these other genera are not found, intergrading specimens are rarely met with. *Atlanticus* is a genus of the Locustidæ which is not common in eastern United States. Two species, *dorsalis* Burm. and *pachymerus* Burm., are described. It has been my fortune to find but one specimen of this genus. It was from Cold Spring Harbor, New York. The ovipositor of this individual is 22 mm. long. Beutenmuller (1904) gives 30 mm. as the length of the ovipositor of *dorsalis* and 20 mm. of *pachymerus*. It is thus, for this character, nearer *pachymerus*. Its posterior femora are 25 mm. long. The femora of *dorsalis* is 27 mm., and of *pachymerus* 22 mm. It is, then, for this character, nearer *dorsalis*. And so with the other less important characters it is decidedly intermediate. I have no doubt that *Atlanticus* is a case like *Gryllus*. Owing to the small number of individuals in the former genus, however, a biometric proof of this would be difficult.

We have in these various genera instances of creatures differing only in the relative sizes of organs possessed in common by all species of their genus. The dimensions of these organs fluctuate in a way which may be described by the law of error, and they are clearly influenced by environment. Evolution within these genera has not progressed by the addition or subtraction of characters, but by the increase or decrease of common characters. There are, apparently, no centers about which the relative sizes of these organs crystallize, so to speak, except in the case of the wing; and here we have only two centers, or, taking a broad view, three, namely, winglessness (not known to me in *Gryllus*), short-wingedness, and long-wingedness. The case of the wing-length satisfies all the criteria of a mutation, but it has not given rise to a species, according to the accepted taxonomic usage, any more than have the fluctuations. It could only give rise to two distinct species at the most, in the genus *Gryllus*, as there are only the two centers about which the wing-length groups itself. Breeding experiments, if they could be carried out, might demonstrate instances of physiological isolation, as in the case of *Gryllus domesticus*, but such experiments upon all of the described species will always be out of the question. The problems concerning the origin of physiological isolation are important. Equally important and not necessarily connected with these are the problems of the origin of diverse external characteristics. In this and other genera mutation may be a factor in physiological isolation, but the origin of the diversity of many of the important external characteristics (hence species?) is indisputably a question of fluctuating variability controlled by environmental conditions.

7. SUMMARY.

No specific entities exist in the genus *Gryllus* which can be demonstrated by any morphological characters thus far studied. "Species" seems to be a human convention of the same sort as "genus." The describing and naming of species here has for its justification convenience of reference.

A large amount of correlation exists between the various taxonomic characters, and this correlation is apparent in the genus as a whole as well as in local samples of it.

Local environmental influences have an effect upon the taxonomic characters; chiefly, in all probability, upon the length of the ovipositor, the most important taxonomic character.

Wing-length is markedly dimorphic. Intergrades between the two conditions were not found. Each group fluctuates about its mean to an extent and in a manner similar to the fluctuation of the monomorphic characters. The dimorphism of the wing affects, through correlation, the size of the other organs, especially the tegmina.

The organs of the short-winged group are more variable and slightly less correlated than those of the long-winged group. Undoubtedly, short-wingedness is the newer condition and a degeneration. The greater variability and lesser correlation may be connected with this fact, but can not be explained by it. The two groups are, within themselves, built upon much the same structural plan, as shown by the regression lines.

Wing-length, both with regard to the relative abundance of the dimorphs and the length of the wing of one of them, seems to be influenced by climatic differences; but the climatic influences are often weaker than local environmental factors.

A study of the variation and correlations of the genus as a whole indicates that local populations are selected samples of it, having different constants but following the same laws of relative variability and correlation of organs.

"Species" within this genus is a question of fluctuating variability, and only in one organ, conspicuous but relatively unimportant, do we find a clear case of mutation.

APPENDIX.

DATA CONCERNING LOCAL COLLECTIONS OF GRYLLUS.

The data given here were obtained by measuring the lengths of the body, tegmina, wings, posterior femora, and ovipositor of females collected from a number of localities in eastern United States and one in Mexico. All the individuals of each collection were caught at practically the same time and in the same environment. Only mature specimens are considered in this paper.

(1) MAINE.

A small collection, made by Miss A. C. Dimon in August, 1903, at Millinocket, in the north-central part of the State, contained 4 females. Their average dimensions and the ranges of variation are given in table 12.

TABLE 12.—*Millinocket, Maine, August, 1903.*

	Average.	Range.	
Body	15.1	12.75 to	18.75
Tegmina	9.1	7.75	10.75
Wings	6.75	6.25	7.25
Posterior femora	10.25	9.75	11.25
Ovipositor	13.1	11.75	14.75

Two collections, also small, were received from Miss Edith M. Patch, State Entomologist of Maine. They were both made at Orono. One was dated October, 1904; the other, June, 1905. Each contained 8 females. Table 13 shows their character.

TABLE 13.—*Orono, Maine.*

	October, 1904.			June, 1905.		
	Average.	Range.		Average.	Range.	
Body	16.3	14.75 to	19.25	14.9	13.25 to	16.25
Tegmina	8.9	8.25	10.25	9.9	9.25	10.75
Wings	6.4	5.75	8.25	7.9	7.25	9.75
Posterior femora	9.8	9.25	10.25	9.4	8.75	9.75
Ovipositor	12.9	11.75	14.25	11.1	10.75	11.75

In September, 1904, I made a collection at Perkins Cove, near York Beach, in southern Maine. *Gryllus* was very abundant and I easily got about 175 females from an area of about 10 ares. The cove is used as a landing-place by fishermen, and refuse in large quantity and variety

furnishes abundant food and protection to crickets. The cove is, furthermore, protected from the majority of the winds, but receives full benefit of the sun's heat. Thus there is here a sort of an island of favorable conditions in the midst of quite unfavorable ones. Indeed, in the country just outside of this small cove *Gryllus* was so scarce as to be practically absent. I was very much surprised to find 22 macropterous females and 4 macropterous males in this collection. They were brought back alive to be used in breeding experiments.

The seriations of the short-winged females are given in table 14. For the reasons stated on page 15 I did not make measurements of the body-length for the entire collection; 20 individuals, picked at random, had an average body-length of 23.4 (range, 20.75 to 27.25).

TABLE 14.—*Variation curves of the Perkins Cove collection.*

Tegmina.		Wings.		Posterior femora.		Ovipositor	
8.5	3	*5.5*	1	*9.25*	1	*12.5*	2
9.5	3	*6.5*	6	*9.75*	1	*13.5*	0
10.5	16	*7.5*	13	*10.25*	0	*14.5*	2
11.5	26	*8.5*	22	*10.75*	2	*15.5*	9
12.5	61	*9.5*	51	*11.25*	12	*16.5*	17
13.5	44	*10.5*	40	*11.75*	21	*17.5*	14
14.5	16	*11.5*	22	*12.25*	33	*18.5*	25
15.5	1	*12.5*	11	*12.75*	27	*19.5*	41
	—	*13.5*	3	*13.25*	25	*20.5*	21
	170		—	*13.75*	16	*21.5*	10
			169	*14.25*	7	*22.5*	3
				14.75	2	*23.5*	3
					—		—
					147		147

The constants of these curves are shown in table 15.

TABLE 15.—*Variation constants of the Perkins Cove collection.*

	Tegmina.	Wings.	Posterior femora.	Ovipositor.
Mean	12.500±0.065	9.849±0.080	12.594±0.051	18.806±0.110
Standard deviation	1.255±0.046	1.544±0.057	0.922±0.036	1.985±0.078
Coefficient of variation	10.04±0.37	15.68 ±0.059	7.32 ±0.29	10.55 ±0.42

The correlations existing between the lengths of these organs are shown in tables 17 to 22. The coefficients calculated from these are given in table 16.

TABLE 16.—*Coefficients of correlation of the Perkins Cove collection.*

	Tegmina.	Wings.	Posterior femora.	Ovipositor.
Wings	0.843±0.015		0.711±0.028	0.764±0.024
Posterior femora	0.841±0.016	0.711±0.028		0.823±0.020
Ovipositor	0.890±0.012	0.764±0·024	0.823±0.020	

Table 17.

WINGS.

TEGMINA.	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	
8.5	1	2								3
9.5		3								3
10.5		1	12	3						16
11.5			1	12	10	3				26
12.5				7	35	12	3	3		60
13.5					6	22	10	5	1	44
14.5						3	8	3	2	16
15.5							1			1
	1	6	13	22	51	40	22	11	3	169

Table 18.

POSTERIOR FEMORA.

TEGMINA.	9.25	9.75	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
8.5		1		1									2
9.5					2	1							3
10.5	1			1	6	5			1				14
11.5					4	7	6	2					19
12.5						8	22	18	6	2			56
13.5							5	6	14	9	2		36
14.5								1	4	5	5	1	16
15.5												1	1
	1	1	0	2	12	21	33	27	25	16	7	2	147

Table 19.

OVIPOSITOR.

TEGMINA.	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	
8.5	2		1										3
9.5				1	1								2
10.5			1	5	7		1						14
11.5				2	8	5	3	1					19
12.5					1	8	16	22	7				54
13.5							5	15	12	3	2		37
14.5								1	2	5	1	3	12
15.5										1			1
	2	0	2	8	17	13	25	39	21	9	3	3	142

Table 20.

POSTERIOR FEMORA.

WINGS.	9.25	9.75	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
6.5		1		1	2	2							6
7.5				1	5	3	1		1				11
8.5	1				3	6	5	3					18
9.5					1	7	16	15	6				45
10.5					1	2	10	4	8	8	2		35
11.5							1	4	5	6	2	1	19
12.5						1		1	2	2	3	1	10
13.5									3				3
	1	1	0	2	12	21	33	27	25	16	7	2	147

TABLE 21.

OVIPOSITOR.

WINGS.	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	
5.5	1												1
6.5	1		1	1	2								5
7.5			1	5	5								11
8.5				2	5	4	5	1					17
9.5					4	6	10	20	5				45
10.5					1	3	4	12	8	3	1	1	33
11.5							2	5	4	5		1	17
12.5							3	1	1	1	2	1	9
13.5									3				3
	2	0	2	8	17	13	24	39	21	9	3	3	141

TABLE 22.

OVIPOSITOR.

POSTERIOR FEMORA.	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	
9.25					1								1
9.75	1												1
10.25													0
10.75			2										2
11.25				4	5	1							10
11.75				2	5	4	6	2					19
12.25				1	2	4	4	12					23
12.75					1	2	8	10	4				25
13.25					1		3	6	8	3			21
13.75							1	5	3	4	1		14
14.25									1		1	3	5
14.75										1	1		2
	1	0	2	7	15	11	22	35	16	8	3	3	123

(2) VERMONT.

Dr. C. D. Howe kindly sent me two collections from Vermont. Their measurements are given in table 23. The one from New Fane (September, 1904) contained 37 females; the one from Essex Junction (September, 1904), 18.

TABLE 23.—*Vermont collections.*

	New Fane.			Essex Junction.		
	Average.	Range.		Average.	Range.	
Body	20.72	16.25 to	24.75	21.18	16.25 to	23.75
Tegmina	11.05	7.75	14.25	11.63	8.25	13.25
Wings	8.04	5.25	12.75	8.83	4.75	13.25
Posterior femora	11.94	10.25	13.25	11.92	9.75	13.25
Ovipositor	16.68	13.75	21.25	16.78	12.75	19.25

(3) MASSACHUSETTS.

I purchased a collection made near Amherst on "fine soil mixed with clay" in the fall of 1901. The females gave the seriations shown in table 24.

TABLE 24.—*Variation curves of the Amherst, Massachusetts, collection.*

Body.		Tegmina.		Wings.		Posterior femora.		Ovipositor.	
12.5	1	*5.5*	6	*3.5*	2	*8.5*	3	*10.5*	1
13.5	1	*6.5*	27	*4.5*	33	*9.5*	30	*11.5*	4
14.5	7	*7.5*	51	*5.5*	80	*10.5*	58	*12.5*	19
15.5	24	*8.5*	44	*6.5*	21	*11.5*	25	*13.5*	56
16.5	34	*9.5*	10	*7.5*	4			*14.5*	40
17.5	40	*10.5*	1	*8.5*	1		116	*15.5*	18
18.5	30							*16.5*	2
19.5	6		139		141			*17.5*	1
	143								141

Unfortunately, I made the measurements of the posterior femora in millimeter classes. I did not, at the time, appreciate the desirability of finer groupings. Since there are only four classes, when grouped in this way, I have not worked out the constants involving the second and higher moments. The average length of the posterior femora in the above seriation is 10.41. The constants of the other curves are given in table 25.

TABLE 25.—*Variation constants of the Amherst collection.*

	Body.	Tegmina.	Wings.	Ovipositor.
Mean	17.010±0.073	7.701±0.055	5.465±0.041	13.897±0.060
Standard deviation	1.300±0.052	0.955±0.039	0.730±0.029	1.052±0.042
Coefficient of variation	7.64 ±0.31	12.40 ±0.51	13.35 ±0.55	7.57 ±0.31

In table 26 are given the coefficients of the various correlations based upon tables 27 to 32.

TABLE 26.—*Coefficients of correlation of the Amherst collection.*

	Body.	Tegmina.	Wings.	Ovipositor.
Tegmina	0.630 ± 0.035		0.763 ± 0.024	0.681 ± 0.031
Wings	0.646 ± 0.033	0.763 ± 0.024		0.665 ± 0.032
Ovipositor	0.729 ± 0.027	0.681 ± 0.031	0.665 ± 0.032	

TABLE 27.

TEGMINA.

BODY.	5.5	6.5	7.5	8.5	9.5	10.5	
12.5	1						1
13.5		1					1
14.5	2	3	2				7
15.5	2	10	10	1	1		24
16.5	1	8	11	12			32
17.5		4	19	14	3		40
18.5		1	9	15	3	1	29
19.5				2	3		5
	6	27	51	44	10	1	139

TABLE 28.

WINGS.

BODY.	3.5	4.5	5.5	6.5	7.5	8.5	
12.5		1					1
13.5		1					1
14.5	1	5	1				7
15.5		14	9				23
16.5	1	7	21	4			33
17.5		3	30	5	2		40
18.5		2	19	8	1		30
19.5				4	1	1	6
	2	33	80	21	4	1	141

Table 29.

OVIPOSITOR.

BODY.	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	
12.5		1							1
13.5		1							1
14.5	1	1	4		1				7
15.5		1	7	14	2				24
16.5			6	18	8	1			33
17.5			2	19	13	4	1		39
18.5				5	15	9	1		30
19.5					1	4		1	6
	1	4	19	56	40	18	2	1	141

Table 30.

WINGS.

TEGMINA.	3.5	4.5	5.5	6.5	7.5	8.5	
5.5	2	4					6
6.5		19	8				27
7.5		9	39	2			50
8.5		1	29	8	4	1	43
9.5			2	8			10
10.5				1			1
	2	33	78	19	4	1	137

Table 31.

OVIPOSITOR.

TEGMINA.	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	
5.5	1	1	2	2					6
6.5		1	13	11	2				27
7.5		2	2	28	16	2	1		51
8.5			1	14	18	8	1		42
9.5				1	3	5		1	10
10.5						1			1
	1	4	18	56	39	16	2	1	137

TABLE 32.

OVIPOSITOR.

WINGS.	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	
3.5	1		1						2
4.5		4	12	12	5				33
5.5			6	39	23	9	1		78
6.5				3	9	8		1	21
7.5					3		1		4
8.5						1			1
	1	4	19	54	40	18	2	1	139

(4) NEW YORK.

A special study of the crickets of Cold Spring Harbor, Long Island, New York, was made with a view toward determining the effects of local differences in the environment. The data presented here are from material collected during September and October, 1904. For a description of the three areas from which collections were made see pages 17 and 18. The seriations are given in table 33.

TABLE 33.—*Variation curves of the Cold Spring Harbor collections.*

Tegmina.				Wings.				Posterior femora.				Ovipositor.			
	Main-land.	Base of spit.	Apex of spit.		Main-land.	Base of spit.	Apex of spit.		Main-land.	Base of spit.	Apex of spit.		Main-land.	Base of spit.	Apex of spit.
8.25	...	...	1	*5.75*	...	1	1	*9.75*	...	2	...	*13.5*	1	...	...
8.75	1	...	0	*6.25*	3	5	5	*10.25*	1	1	2	*14.5*	2	...	...
9.25	2	3	6	*6.75*	4	19	18	*10.75*	7	13	10	*15.5*	8	4	...
9.75	3	18	10	*7.25*	17	27	45	*11.25*	20	27	16	*16.5*	28	14	4
10.25	5	15	23	*7.75*	27	53	50	*11.75*	43	43	68	*17.5*	59	34	16
10.75	17	34	34	*8.25*	48	64	67	*12.25*	54	55	52	*18.5*	53	54	44
11.25	32	34	52	*8.75*	47	38	37	*12.75*	40	54	51	*19.5*	40	61	63
11.75	42	62	54	*9.25*	27	28	15	*13.25*	24	36	29	*20.5*	6	48	55
12.25	42	33	37	*9.75*	22	12	8	*13.75*	9	11	12	*21.5*	5	15	41
12.75	27	32	19	*10.25*	5	3	2	*14.25*	3	0	1	*22.5*	3	13	8
13.25	18	10	10	*10.75*	3	0	...	*14.75*	2	1	1	*23.5*	...	1	2
13.75	7	7	...	*11.25*	3	1	...					*24.5*	...	...	0
14.25	3	1	...									*25.5*	...	...	1
	199	249	246		206	251	248		203	243	242		205	244	234

These curves give the constants shown in table 34.

TABLE 34.—*Variation constants of the Cold Spring Harbor collections.*

[*a*, mainland; *b*, base of spit; *c*, apex of spit.]

		Tegmina.	Wings.	Posterior femora.	Ovipositor.
Mean	*a*	11.961±0.046	8.578±0.043	12.321±0.037	18.144±0.067
	b	11.601±0.043	8.168±0.037	12.279±0.035	19.258±0.067
	c	11.423±0.040	8.008±0.034	12.283±0.033	19.872±0.061
Standard deviation	*a*	0.995±0.032	0.915±0.030	0.782±0.026	1.421±0.047
	b	1.009±0.030	0.865±0.026	0.807±0.025	1.550±0.047
	c	0.919±0.028	0.790±0.024	0.753±0.023	1.389±0.043
Coefficient of variability	*a*	7.98 ±0.27	10.66 ±0.36	6.34 ±0.21	7.83 ±0.26
	b	8.69 ±0.26	10.59 ±0.32	6.58 ±0.20	8.05 ±0.25
	c	8.05 ±0.25	9.87 ±0.30	6.13 ±0.18	6.99 ±0.22

The data from which the coefficients of correlation (table 35) were calculated are given in tables 36 to 53.

TABLE 35.—*Coefficients of correlation of the Cold Spring Harbor collections.*

		Tegmina.	Wings.	Posterior femora.	Ovipositor.
Wings	*a*	0.833±0.015		0.605±0.030	0.647±0.028
	b	0.901±0.008		0.706±0.022	0.616±0.027
	c	0.897±0.008		0.665±0.024	0.530±0.032
Posterior femora	*a*	0.777±0.019	0.605±0.030		0.749±0.021
	b	0.794±0.016	0.706±0.022		0.725±0.021
	c	0.742±0.020	0.665±0.024		0.737±0.021
Ovipositor	*a*	0.754±0.021	0.647±0.028	0.749±0.021	
	b	0.683±0.023	0.616±0.027	0.725±0.021	
	c	0.639±0.026	0.530±0.032	0.737±0.021	

TABLE 36.—*Mainland.*

WINGS.

TEGMINA.	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75	10.25	10.75	11.25	
8.75	1											1
9.25	2											2
9.75		1	2									3
10.25		2	3									5
10.75		1	5	8	1	2						17
11.25			5	12	14		1					32
11.75			1	5	24	9	2	1				42
12.25					8	21	9		1	1	1	41
12.75						7	6	11	2	1		27
13.25						6	5	5			2	18
13.75							2	3	2			7
14.25								2		1		3
	3	4	16	25	47	45	25	22	5	3	3	198

TABLE 37.—*Base of spit.*

WINGS.

TEGMINA.	5.75	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75	10.25	10.75	11.25	
9.25	1	1	1										3
9.75		4	8	5	1								18
10.25			7	6	2								15
10.75			3	11	17	3							34
11.25				5	16	11	1	1					34
11.75					14	35	11	2					62
12.25					2	14	11	6					33
12.75						1	13	14	3			1	32
13.25							2	3	4	1			10
13.75								1	4	2			7
14.25									1				1
	1	5	19	27	52	64	38	27	12	3	0	1	249

TABLE 38.—*Apex of spit.*

WINGS.

TEGMINA.	5.75	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75	10.25	
8.25	1										1
8.75											0
9.25		3	3								6
9.75		1	8	1							10
10.25			5	16	2						23
10.75		1	1	16	13	1	1				33
11.25				11	23	15	3				52
11.75					10	35	8				53
12.25					2	12	17	4	1	1	37
12.75						1	6	9	3		19
13.25						1	2	2	4	1	10
	1	5	17	44	50	65	37	15	8	2	244

TABLE 39.—*Mainland.*

POSTERIOR FEMORA.

TEGMINA.	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
8.75		1									1
9.25		2									2
9.75		1	2								3
10.25		2	1	1	1						5
10.75	1		6	8	2						17
11.25			5	12	13	1					31
11.75		1	3	12	15	9	1				41
12.25			1	4	12	13	10				40
12.75			1	1	7	9	7	1			26
13.25				1		5	4	6	1		17
13.75						2	1	2	2		7
14.25					1					2	3
	1	7	19	39	51	39	23	9	3	2	193

TABLE 40.—*Base of spit.*

POSTERIOR FEMORA.

TEGMINA.	9.75	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
9.25	1		1	1								3
9.75	1	1	6	4	4	2						18
10.25			3	4	4	4						15
10.75			3	13	13	4	1					34
11.25				5	8	8	9	2				32
11.75					10	23	21	5	1			60
12.25					2	9	11	6	3			31
12.75					1	4	9	14	3			31
13.25						1	2	4	2			9
13.75								5	2			7
14.25											1	1
	2	1	13	27	42	55	53	36	11	0	1	241

TABLE 41.—*Apex of spit.*

POSTERIOR FEMORA.

TEGMINA.	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
8.25	1										1
8.75											0
9.25		4	2								6
9.75	1	2	2	5							10
10.25		3	4	13	3						23
10.75			5	15	6	8					34
11.25		1	3	18	7	16	3				48
11.75				13	23	11	3	3			53
12.25				3	8	13	9	3	1		37
12.75					3	3	7	2		1	16
13.25							6	4			10
	2	10	16	67	50	51	28	12	1	1	238

TABLE 42.—*Mainland.*

OVIPOSITOR.

TEGMINA.	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	
8.75		1									1
9.25	1		1								2
9.75		1	1	1							3
10.25				3	1	1					5
10.75			3	6	7		1				17
11.25				9	12	9	1				31
11.75			1	8	17	13	3				42
12.25					12	16	10	3			41
12.75				1	7	7	11				26
13.25						3	9	3	2	1	18
13.75						2	2		2	1	7
14.25							1		1	1	3
	1	2	6	28	56	51	38	6	5	3	196

TABLE 43.—*Base of spit.*

OVIPOSITOR.

TEGMINA.	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	
9.25	1	1	1							3
9.75	2	6	5	4	1					18
10.25	1	1	6	7						15
10.75		3	9	14	4	4				34
11.25		1	6	6	12	5	4			34
11.75		2	5	13	24	9	3	2		58
12.25			2	9	9	7	3	1		31
12.75				1	8	15	3	5		32
13.25					2	3		4	1	10
13.75						3	2	1		6
14.25						1				1
	4	14	34	54	60	47	15	13	1	242

TABLE 44.—*Apex of spit.*

OVIPOSITOR.

TEGMINA.	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	
8.25	1										1
8.75											0
9.25		3	3								6
9.75	2	1	4	2							9
10.25	1	5	7	4	4	1					22
10.75		2	9	14	4	2					31
11.25		5	8	16	15	4					48
11.75			8	16	14	13		1			52
12.25			4	7	9	11	5				36
12.75					7	7	1			1	16
13.25				1	2	3	2	1			9
	4	16	43	60	55	41	8	2	0	1	230

TABLE 45.—*Mainland.*

POSTERIOR FEMORA.

WINGS.	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
6.25		3									3
6.75		1	1	2							4
7.25		2	4	6	5						17
7.75	1		5	9	9	2					26
8.25			6	14	15	8	4				47
8.75		1	4	5	13	11	8	2	1		45
9.25				4	3	9	8	2	1		27
9.75					7	6	3	4		1	21
10.25					1	3			1		5
10.75				1		1				1	3
11.25					1		1	1			3
	1	7	20	41	54	40	24	9	3	2	201

TABLE 46—*Base of spit.*

POSTERIOR FEMORA.

WINGS.	9.75	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
5.75			1									1
6.25	2			3								5
6.75		1	7	3	4	4						19
7.25			3	7	8	5	3					26
7.75			2	10	19	10	10	1	1			53
8.25				2	8	25	16	8	1			60
8.75				1	2	8	14	11	1			37
9.25				1	1	2	9	8	6			27
9.75						1	2	6	1		1	11
10.25								2	1			3
10.75												0
11.25					1							1
	2	1	13	27	43	55	54	36	11	0	1	243

TABLE 47.—*Apex of spit.*

POSTERIOR FEMORA.

WINGS.	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
5.75	1										1
6.25		3	1	1							5
6.75	1	5	5	6		1					18
7.25		2	5	20	8	7	2				44
7.75			4	22	10	10	1	1	1		49
8.25				16	22	15	8	3			64
8.75			1	3	8	14	8	2			36
9.25					2	3	7	3			15
9.75					1		1	3		1	6
10.25					1		1				2
	2	10	16	68	52	50	28	12	1	1	240

TABLE 48—*Mainland.*

OVIPOSITOR.

WINGS.	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	
6.25	1	1	1								3
6.75			1	2	1						4
7.25		1	1	9	2	3	1				17
7.75			3	3	13	6	1				26
8.25			1	9	21	14	3				48
8.75			1	4	12	13	15	1			46
9.25				1	5	9	7	3	2		27
9.75					2	5	10	1	1	2	21
10.25					1	1	1	1	1		5
10.75					1		1			1	3
11.25						1	1		1		3
	1	2	8	28	58	52	40	6	5	3	203

TABLE 49.—*Base of spit.*

OVIPOSITOR.

WINGS.	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	
5.75		1								1
6.25	3		1	1						5
6.75		4	9	5	1					19
7.25		4	7	8	4	4				27
7.75	1	4	7	19	14	2	4	1		52
8.25		1	8	15	18	16	3	1		62
8.75			1	2	15	11	3	4	1	37
9.25			1	4	7	9	2	3		26
9.75					1	5	3	3		12
10.25						1		1		2
10.75										0
11.25					1					1
	4	14	34	54	61	48	15	13	1	244

TABLE 50.—*Apex of spit.*

OVIPOSITOR.

WINGS.	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	
5.75	1										1
6.25		1	2	1							4
6.75	2	4	6	4		1					17
7.25	1	6	10	12	9	4					42
7.75		2	12	19	11	2	1				47
8.25		2	9	17	17	16	1	1			63
8.75		1	3	8	11	8	4				35
9.25			1		4	6	1	1			13
9.75			1		2	3	1			1	8
10.25				1	1						2
	4	16	44	62	55	40	8	2	0	1	232

TABLE 51.—*Mainland.*

OVIPOSITOR.

POSTERIOR FEMORA.	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	
10.25			1								1
10.75	1	1	1	3	1						7
11.25		1	3	6	8	2					20
11.75			3	9	21	9	1				43
12.25				7	19	18	8				52
12.75				2	6	13	15	4			40
13.25				1	3	9	9	1	1		24
13.75						1	4	1	1	2	9
14.25							1		2		3
14.75									1	1	2
	1	2	8	28	58	52	38	6	5	3	201

TABLE 52.—*Base of spit.*

OVIPOSITOR.

POSTERIOR FEMORA.	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	
9.75	2									2
10.25		1								1
10.75		6	4	3						13
11.25	2	3	7	13	2					27
11.75		3	13	13	8	3	2			42
12.25		1	8	15	20	8	2			54
12.75				7	20	18	4	3		52
13.25				2	9	12	5	5	1	34
13.75				1	1	5	1	3		11
14.25										0
14.75						1				1
	4	14	32	54	60	47	14	11	1	237

TABLE 53.—*Apex of spit.*

OVIPOSITOR.

POSTERIOR FEMORA.	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5	25.5	
10.25	2										2
10.75		3	6								9
11.25	2	5	5	2							14
11.75		4	19	29	11	2					65
12.25		1	12	13	13	10	1				50
12.75		1	2	15	17	10	2				47
13.25				3	6	15	2				26
13.75					4	3	2	2			11
14.25							1				1
14.75										1	1
	4	14	44	62	51	40	8	2	0	1	226

(5) VIRGINIA AND NORTH CAROLINA.

Mr. A. A. Girault kindly sent me 30 *Gryllus* from Blacksburg, Virginia, collected June 25, 1902. There were 15 short-winged and 2 long-winged females. The 13 males were all short-winged.

A collection from Danbury, North Carolina, was obtained through the kindness of J. E. Miller, September, 1901. It contained 10 short-winged and 3 long-winged females, and 11 short-winged and 2 long-winged males.

Table 54 gives the averages and ranges of variation for these two collections.

TABLE 54.

	Short-winged.		Long-winged.	
	Average.	Range.	Average.	Range.
Blacksburg, Virginia:				
Body	18.71	15.5 to 22.5	18.50	18.5
Tegmina	10.10	9.5 11.5	11.50	11.5
Wings	8.30	7.5 9.5	21.00	20.5 to 21.5
Posterior femora	11.08	10.5 12.5	11.50	11.5
Ovipositor	12.71	11.5 13.5	11.50	11.5
Danbury, North Carolina:				
Body	19.83	17.5 to 21.5	20.00	19.5 to 20.5
Tegmina	10.83	8.5 12.5	14.17	13.5 14.5
Wings	8.80	7.5 9.5	23.83	23.5 24.5
Posterior femora	12.17	11.5 12.5	12.83	12.5 13.5
Ovipositor	13.50	12.5 14.5	14.17	13.5 14.5

(6) FLORIDA.

A collection of *Gryllus* from Gotha, Florida, was purchased. The collector obtained them in September, 1903, from one field of stony waste land. The seriations are given in table 55.

TABLE 55.—*Variation curves of the Gotha, Florida, collection.*

Body.			Tegmina.			Wings.				Posterior femora.			Ovipositor.		
	Short-winged.	Long-winged.		Short-winged.	Long-winged.	Short-winged.		Long-winged.			Short-winged.	Long-winged.		Short-winged.	Long-winged.
16.5	2	1	*11.75*	1	...	*9.25*	3	*20.75*	5	*11.25*	3	2	*13.75*	4	...
17.5	4	4	*12.25*	7	...	*9.75*	1	*21.25*	5	*11.75*	10	14	*14.25*	4	1
18.5	11	25	*12.75*	8	1	*10.25*	11	*21.75*	6	*12.25*	11	22	*14.75*	8	10
19.5	20	31	*13.25*	16	5	*10.75*	11	*22.25*	22	*12.75*	13	37	*15.25*	9	14
20.5	11	38	*13.75*	15	13	*11.25*	15	*22.75*	21	*13.25*	5	29	*15.75*	12	14
21.5	6	27	*14.25*	10	31	*11.75*	8	*23.25*	26	*13.75*	6	18	*16.25*	9	35
22.5	5	7	*14.75*	2	43	*12.25*	8	*23.75*	27	*14.25*	1	3	*16.75*	7	25
23.5	...	4	*15.25*	3	34	*12.75*	3	*24.25*	15	*14.75*	1	0	*17.25*	5	24
24.5	...	1	*15.75*	1	17	*13.25*	2	*24.75*	17	*15.25*	...	1	*17.75*	1	10
			16.25	...	8	*13.75*	2	*25.25*	3				*18.25*	2	9
	59	138	*16.75*	...	3			*25.75*	5		50	126	*18.75*	...	2
			17.25	...	1		64	*26.25*	1						
								26.75	2					61	144
				63	156										
									155						

The constants of this collection are given in table 56.

TABLE 56.—*Variation constants of the Gotha, Florida, collection.*

[*a*, short-winged; *b*, long-winged.]

		Body.	Tegmina.	Wings.	Posterior femora.	Ovipositor.
Mean	*a*	19.720±0.124	13.512±0.070	11.293±0.084	12.590±0.075	15.742±0.093
	b	20.210±0.080	14.856±0.042	23.369±0.065	12.841±0.041	16.504±0.054
Standard deviation	*a*	1.410±0.088	0.818±0.049	0.999±0.060	0.783±0.053	1.079±0.066
	b	1.391±0.056	0.771±0.029	1.200±0.046	0.682±0.029	0.961±0.038
Coefficient of variability	*a*	7.15±0.45	6.05±0.36	8.86±0.53	6.22±0.42	6.85±0.42
	b	6.88±0.28	5.19±0.20	5.14±0.20	5.31±0.23	5.82±0.23

See tables 58 to 77 for the details of the correlation data. These give the coefficients shown in table 57.

TABLE 57.—*Coefficients of correlation of the Gotha, Florida, collection.*

[*a*, short-winged; *b*, long-winged.]

		Tegmina.	Wings.	Posterior femora.	Ovipositor.
Body	*a*	0.602±0.057	0.549±0.065	0.538±0.070	0.670±0.050
	b	0.575±0.039	0.489±0.044	0.569±0.041	0.557±0.041
Tegmina	*a*		0.860±0.022	0.861±0.025	0.767±0.036
	b		0.930±0.008	0.773±0.024	0.776±0.022
Wings	*a*	0.860±0.022		0.682±0.051	0.714±0.042
	b	0.930±0.008		0.736±0.028	0.747±0.025
Posterior femora	*a*	0.861±0.025	0.682±0.051		0.836±0.032
	b	0.773±0.024	0.736±0.028		0.770±0.025
Ovipositor	*a*	0.767±0.036	0.714±0.042	0.836±0.032	
	b	0.776±0.022	0.747±0.025	0.770±0.025	

TABLE 58.—*Short-winged.*

TEGMINA.

BODY.	11.5	12.5	13.5	14.5	15.5	
16.5		2				2
17.5		2	2			4
18.5	1	3	6	1		11
19.5		6	11	2	1	20
20.5		1	4	5	1	11
21.5			2	2		4
22.5			1	1	2	4
	1	14	26	11	4	56

TABLE 59.—*Long-winged.*

TEGMINA.

BODY.	12.5	13.5	14.5	15.5	16.5	17.5	
17.5		3			1		4
18.5	1	8	12	3	1		25
19.5		4	21	5			30
20.5		2	15	19	2		38
21.5			14	12	1		27
22.5			1	6			7
23.5					3	1	4
24.5					1		1
	1	17	63	45	9	1	136

TABLE 60.—*Short-winged.*

WINGS.

BODY.	9.25	9.75	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	
16.5	1	1									2
17.5			2	1		1					4
18.5	1		3	2	3	1			1		11
19.5			6	4	5	2	2			1	20
20.5				3	2	3	2				10
21.5					1		2				3
22.5						1	1			1	3
	2	1	11	10	11	8	7	0	1	2	53

TABLE 61.—*Long-winged.*

WINGS.

BODY.	20.75	21.25	21.75	22.25	22.75	23.25	23.75	24.25	24.75	25.25	25.75	26.25	26.75	
17.5	1			1							1			3
18.5	1	3	4	4	6	2	3		1		1			25
19.5	2	2	2	7	1	8	3	5		1				31
20.5				3	4	6	10	6	8		1			38
21.5				4	5	5	7	3	2				1	27
22.5					1		2	1	2					6
23.5										1	1	1	1	4
24.5										1				1
	4	5	6	19	17	21	25	15	13	3	4	1	2	135

TABLE 62.—*Short-winged.*

POSTERIOR FEMORA.

BODY.	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
16.5			1	1					2
17.5		1	2	1					4
18.5	2	4	2	3					11
19.5	1	4	3	4		2			14
20.5		1	1	1	2	3		1	9
21.5				2	1	1			4
22.5					2		1		3
	3	10	9	12	5	6	1	1	47

TABLE 63.—*Long-winged.*

POSTERIOR FEMORA.

BODY.	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	15.25	
17.5			2							2
18.5	1	5	8	5	2		1			22
19.5	1	8	4	9	6	1				29
20.5		1	5	11	8	8				33
21.5			3	10	8	3				24
22.5				2	4	1				7
23.5						2	1		1	4
24.5							1			1
	2	14	22	37	28	15	3	0	1	122

TABLE 64.—*Short-winged.*

OVIPOSITOR.

BODY.	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	
16.5	1		1								2
17.5	1			1		2					4
18.5	1	2	3	2	2						10
19.5	1	2	2	4	6	3	1	1			20
20.5			2		2	1	3	2	1		11
21.5						1	3				4
22.5						1		1		2	4
	4	4	8	7	10	8	7	4	1	2	55

TABLE 65.—*Long-winged.*

OVIPOSITOR.

BODY.	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	
17.5			1	1	1						3
18.5		3	6	3	6	4	1		1		24
19.5	1	5	3	4	10	2	1	3			29
20.5			3	2	11	7	9	2	2		36
21.5		1	1		7	8	6	1	2		26
22.5				1			2	1	3		7
23.5								1	1	2	4
24.5								1			1
	1	9	14	11	35	21	19	9	9	2	130

TABLE 66.—*Short-winged.*

WINGS.

TEGMINA.	9.25	9.75	10.25	10.75	11.25	11.75	12.25	12.75	13.25	13.75	
11.75	1										1
12.25	1	1	3	2							7
12.75	1		4	2	1						8
13.25			3	6	5	1	1				16
13.75			1	1	6	5	2				15
14.25					2	2	3	1	2		10
14.75							1	1			2
15.25							1	1		1	3
15.75										1	1
	3	1	11	11	14	8	8	3	2	2	63

TABLE 67.—*Long-winged.*

WINGS.

TEGMINA.	20.75	21.25	21.75	22.25	22.75	23.25	23.75	24.25	24.75	25.25	25.75	26.25	26.75	
12.75		1												1
13.25	1	2	2											5
13.75	3	2	2	5	1									13
14.25	1		2	14	9	5								31
14.75				3	11	15	9	3	1					42
15.25						6	17	7	4					34
15.75							1	5	10	1				17
16.25									2	2	4			8
16.75											1	1	1	3
17.25													1	1
	5	5	6	22	21	26	27	15	17	3	5	1	2	155

TABLE 68.—*Short-winged.*

POSTERIOR FEMORA.

TEGMINA.	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
11.75	1								1
12.25	1	3	1	1					6
12.75	1	4	1	1					7
13.25		3	5	2	1				11
13.75			4	5	2				11
14.25				4	2	4			10
14.75						1			1
15.25						1	1		2
15.75								1	1
	3	10	11	13	5	6	1	1	50

TABLE 69.—*Long-winged.*

POSTERIOR FEMORA.

TEGMINA.	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	15.25	
12.75		1								1
13.25		3	1							4
13.75	1	4	3	1						9
14.25	1	4	7	10	2					24
14.75		2	7	15	8	1				33
15.25			2	9	11	9				31
15.75			2	2	6	3				13
16.25					1	3	3			7
16.75						2				2
17.25									1	1
	2	14	22	37	28	18	3	0	1	125

TABLE 70.—*Short-winged.*

OVIPOSITOR.

TEGMINA.	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	
11.75	1										1
12.25	2	1	4								7
12.75		1	2	1	2	2					8
13.25	1	2	2	4	3	2	1				15
13.75				4	4	3	1	2			14
14.25					2		4	2		1	9
14.75						1	1				2
15.25						1		1		1	3
15.75									1		1
	4	4	8	9	11	9	7	5	1	2	60

TABLE 71.—*Long-winged.*

OVIPOSITOR.

TEGMINA.	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	
12.75			1								1
13.25		3			1						4
13.75	1	3	4	2	2						12
14.25		4	7	8	7	2	2				30
14.75			1	4	17	11	4	2	1		40
15.25			1		8	7	9	3	3		31
15.75				1		3	8	1	2		15
16.25						1	1	4	2		8
16.75									1	1	2
17.25										1	1
	1	10	14	15	35	24	24	10	9	2	144

TABLE 72.—*Short-winged.*

POSTERIOR FEMORA.

WINGS.	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	
9.25	1		1	1					3
9.75			1						1
10.25	1	5	2	2					10
10.75		3	3						6
11.25	1	1	2	5	1	1			11
11.75		1	2	2	1	1			7
12.25				1	2	3	1		7
12.75				1					1
13.25				1	1				2
13.75						1		1	2
	3	10	11	13	5	6	1	1	50

TABLE 73.—*Long-winged.*

POSTERIOR FEMORA.

WINGS.	11.25	11.75	12.25	12.75	13.25	13.75	14.25	14.75	15.25	
20.75		1	1	2						4
21.25		4			1					5
21.75		3	2	1						6
22.25	2	5	6	3						16
22.75		1	4	7	3					15
23.25			5	9	6	2				22
23.75			2	8	8	5				23
24.25			2	4	5	3				14
24.75				3	5	3				11
25.25						2	1			3
25.75					1	1	2			4
26.25						1				1
26.75						1			1	2
	2	14	22	37	29	18	3	0	1	126

TABLE 74.—*Short-winged.*

OVIPOSITOR.

WINGS.	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	
9.25	1		1	1							3
9.75	1										1
10.25	1	2	3	3	1	1					11
10.75			4	1	3	2					10
11.25		2		2	4	2	3	1			14
11.75	1			2	2	1	1	1			8
12.25					2	2	2	2			8
12.75						1	1			1	3
13.25										1	1
13.75								1	1		2
	4	4	8	9	12	9	7	5	1	2	61

TABLE 75.—*Long-winged.*

OVIPOSITOR.

WINGS.	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	
20.75	1		1	1							3
21.25		2	1	1	1						5
21.75		4	1	1							6
22.25		3	9	3	4	1					20
22.75			1	2	8	6	3		1		21
23.25		1		4	10	4	3	1			23
23.75			1	1	6	5	8	3	2		26
24.25					4	5	3	2			14
24.75				1	1	3	6	1	3		15
25.25							1	1	1		3
25.75						1		2	1		4
26.25										1	1
26.75									1	1	2
	1	10	14	14	34	25	24	10	9	2	143

TABLE 76.—*Short-winged.*

OVIPOSITOR.

POSTERIOR FEMORA.	13.75	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	
11.25		2									2
11.75	2	1	3	1	2						9
12.25			1	3	2	1					7
12.75				3	3	3	2				11
13.25							1	2		1	4
13.75					1		3	2			6
14.25											0
14.75									1		1
	2	3	4	7	8	4	6	4	1	1	40

TABLE 77.—*Long-winged.*

OVIPOSITOR.

POSTERIOR FEMORA.	14.25	14.75	15.25	15.75	16.25	16.75	17.25	17.75	18.25	18.75	
11.25			1	1							2
11.75		6	6		2						14
12.25		1	2	7	9	2	1				22
12.75	1	2	2	2	16	8	4		1		36
13.25				1	8	5	7	5	2		28
13.75						4	6	2	4	1	17
14.25								2	1		3
14.75											0
15.25										1	1
	1	9	11	11	35	19	18	9	8	2	123

(8) MEXICO.

I am obliged to Mr. Wm. L. Tower for a collection of 33 females and 12 males from Cuernavaca, Mexico. They were caught July 14–20, 1905, on a "fine grass-covered lawn; soil fine, soft, deep, with much humus, always moist through artificial watering."

The collection is rather small for biometrical treatment and Cuernavaca is not strictly comparable with the other localities considered here. The collection is interesting because it is composed entirely of

long-winged individuals. A biometrical survey of the *Gryllus* of Mexico would probably yield valuable information concerning the relation between physiography and the taxonomic characters, as in Mexico we find striking physiographic differences within a relatively small area.

The means and ranges of variation of the females of this collection are given in table 78.

Table 78.—*Cuernavaca, Mexico.*

	Average.	Range.	
Body	19.13	17.25 to	22.75
Tegmina	13.42	11.75	16.25
Wings	22.60	20.75	25.75
Posterior femora	12.22	10.75	13.25
Ovipositor	16.02	12.75	17.75

DATA CONCERNING GRYLLUS IN GENERAL.

The viewpoint here and the sources of the data are mentioned on page 13. The seriations are given in table 79, the variation constants in table 80, and the coefficients of correlation in table 81. Tables 82 to 93 give the details of the correlation data.

Table 79—*Interspecific variation curves.*

Body.			Tegmina.			Posterior femora.			Ovipositor.		
	Short-winged.	Long-winged.		Short-winged.	Long-winged.		Short-winged.	Long-winged.		Short-winged.	Long-winged.
9	1	2	*4*	4	...	*7*	5	6	*5*	2	3
11	3	4	*6*	9	5	*9*	11	14	*7*	5	4
13	2	6	*8*	8	5	*11*	16	45	*9*	5	6
15	10	9	*10*	17	11	*13*	16	37	*11*	7	17
17	16	30	*12*	11	39	*15*	6	26	*13*	9	32
19	10	42	*14*	6	55	*17*	1	6	*15*	12	27
21	8	29	*16*	1	23	*19*	...	1	*17*	10	24
23	4	16	*18*	1	5				*19*	1	14
25	1	5					55	135	*21*	1	5
27	2	2		57	143				*23*	1	5
29	...	1							*25*	...	2
	57	146								53	139

Table 80.—*Interspecific variation constants.*

[*a*, short-winged; *b*, long-winged.]

		Body.	Tegmina.	Posterior femora.	Ovipositor.
Mean	*a*	17.877±0.326	9.719±0.274	11.364±0.210	13.151±0.361
	b	18.959±0.189	13.119±0.137	12.259±0.136	14.741±0.224
Standard deviation	*a*	3.645±0.230	3.068±0.194	2.314±0.149	3.898±0.255
	b	3.379±0.133	2.432±0.097	2.336±0.096	3.920±0.159
Coefficient of variability	*a*	20.39±1.34	31.57±2.18	20.36±1.36	29.64±2.11
	b	17.82±0.73	18.53±0.76	19.06±0.81	26.60±1.15

TABLE 81.—*Interspecific coefficients of correlation.*

[*a*, short-winged; *b*, long-winged.]

		Tegmina.	Posterior femora.	Ovipositor.
Body	*a*	0.719±0.043	0.862±0.023	0.720±0.045
	b	0.864±0.014	0.854±0.016	0.699±0.029
Tegmina	*a*		0.701±0.052	0.541±0.066
	b		0.839±0.017	0.709±0.029
Posterior femora	*a*	0.701±0.052		0.739±0.042
	b	0.839±0.017		0.816±0.020
Ovipositor	*a*	0.541±0.066	0.739±0.042	
	b	0.709±0.029	0.816±0.020	

TABLE 82.—*Short-winged.*

TEGMINA.

BODY.	4	6	8	10	12	14	16	18	
9		1							1
11		2	1						3
13	1		1						2
15	2	2	3	3					10
17	1	3	2	8	2				16
19			1	3	4	2			10
21				2	4	2			8
23		1		1	1		1		4
25						1			1
27						1		1	2
	4	9	8	17	11	6	1	1	57

TABLE 83.—*Long-winged.*

TEGMINA.

BODY.	6	8	10	12	14	16	18	
9	2							2
11	2	2						4
13	1	3	2					6
15			4	4	1			9
17			5	17	7	1		30
19				14	24	2		40
21				3	18	7	1	29
23				1	4	8	2	15
25					1	3	1	5
27							1	1
29						1		1
	5	5	11	39	55	22	5	142

TABLE 84.—*Short-winged.*

POSTERIOR FEMORA.

BODY.	7	9	11	13	15	17	
9	1						1
11	3						3
13	1	1					2
15		7	3				10
17		3	7	5	1		16
19			4	5	1		10
21			2	4	1		7
23				2	2		4
25							0
27					1	1	2
	5	11	16	16	6	1	55

TABLE 85.—*Long-winged.*

POSTERIOR FEMORA.

BODY.	7	9	11	13	15	17	19	
9	1							1
11	2	1						3
13	3	3						6
15		4	5					9
17		3	17	3	1			24
19		3	18	15	5			41
21			5	17	6			28
23				2	11	3		16
25					2	1	1	4
27						2		2
29					1			1
	6	14	45	37	26	6	1	135

TABLE 86.—*Short-winged.*

OVIPOSITOR.

BODY.	5	7	9	11	13	15	17	19	21	23	
9	1										1
11	1	1	1								3
13		1				1					2
15		2	1	3	3						9
17			3	4	1	3	4				15
19		1			4		5				10
21					1	4	1		1		7
23						3					3
25						1					1
27								1		1	2
	2	5	5	7	9	12	10	1	1	1	53

TABLE 87.—*Long-winged.*

OVIPOSITOR.

BODY.	5	7	9	11	13	15	17	19	21	23	25	
9	1	1										2
11	2	2										4
13			6									6
15				2	3	2	1					8
17				7	11	4	5	1				28
19		1		6	13	8	8	3	2		1	42
21				2	4	9	5	6	1			27
23					1	3	2	3	1	4	1	15
25						1	2	1		1		5
27							1					1
29									1			1
	3	4	6	17	32	27	24	14	5	5	2	139

TABLE 88.—*Short-winged.*

POSTERIOR FEMORA.

TEGMINA.	7	9	11	13	15	17	
4	1	3					4
6	3	1	3	1	1		9
8	1	4	1	2			8
10		3	9	5			17
12			3	5	3		11
14				2	2		4
16				1			1
18						1	1
	5	11	16	16	6	1	55

TABLE 89.—*Long-winged.*

POSTERIOR FEMORA.

TEGMINA.	7	9	11	13	15	17	19	
6	3							3
8	3	2						5
10		8	3					11
12		3	23	8	2			36
14		1	16	23	10			50
16			1	5	13	3		22
18			1		1	2	1	5
	6	14	44	36	26	5	1	132

TABLE 90.—*Short-winged.*

OVIPOSITOR.

TEGMINA.	5	7	9	11	13	15	17	19	21	23	
4		1		3							4
6	2	1	1	1	1	2	1				9
8			3		2	2					7
10		2	1	2	2	4	5				16
12		1		1	3	1	3		1		10
14					1	2	1	1			5
16						1					1
18										1	1
	2	5	5	7	9	12	10	1	1	1	53

TABLE 91.—*Long-winged.*

OVIPOSITOR.

TEGMINA.	5	7	9	11	13	15	17	19	21	23	25	
6	3	1	1									5
8		2	3									5
10			2	5	3							10
12		1		4	17	8	5		1	1	1	38
14				7	9	14	12	11				53
16				1	1	4	5	3	4	3	1	22
18						1				1		2
	3	4	6	17	30	27	22	14	5	5	2	135

TABLE 92.—*Short-winged.*

OVIPOSITOR.

POSTERIOR FEMORA.	5	7	9	11	13	15	17	19	21	23	
7	2	2	1								5
9		1	1	4	2	2					10
11		2	3	2	2	2	5				16
13				1	5	6	2		1		15
15						1	3	1			5
17										1	1
	2	5	5	7	9	11	10	1	1	1	52

TABLE 93.—*Long-winged.*

OVIPOSITOR.

POSTERIOR FEMORA.	5	7	9	11	13	15	17	19	21	23	25	
7	2	1	3									6
9		2	3	5	3							13
11				11	20	5	6		1			43
13				1	7	15	7	5			1	36
15						3	6	9	3	3	1	25
17						1	2		1	1		5
19										1		1
	2	3	6	17	30	24	21	14	5	5	2	129

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